SAVING SPACE: WILDLIFE RESEARCH ON KENNEDY SPACE CENTER, FLORIDA

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Kennedy Space Center (KSC) is 57,000 ha of land and lagoons located on the east central coast of Florida. Owned by the National Aeronautics and Space Administration (NASA), the 55,000 ha not used for space operations are managed by the U.S. Fish and Wildlife Service (USFWS) as Merritt Island National Wildlife Refuge, and the National Park Service as Canaveral National Seashore (CNS). KSC is adjacent to Cape Canaveral Air Force Station (CCAFS) which is under the jurisdiction of the U.S. Air Force. Most of KSC is located on northern Merritt Island and forms a barrier island complex with Cape Canaveral. The resulting topography is a ridge and swale system of relict dunes that intergrades a variety of uplands with fresh and brackish water wetlands. KSC is in a transition zone between the temperate and subtropical biotic provinces. These characteristics have given rise to a remarkably diverse assemblage of plants and animals.

Fourteen species of animals federally listed as threatened or endangered regularly occur on KSC, as well as 15 species that are under review for federal listing. Forty wildlife species on KSC are protected by Florida state laws. In order to responsibly manage this resource and comply with legal mandates, NASA has established a long-term environmental monitoring and research program that includes studying the effects of the space program on wildlife and wildlife habitat. Effects result not only from Space Shuttle launches, but also from new construction and ongoing operations. To answer specific questions, studies are conducted on focal wildlife species which are particularly vulnerable to development and whose status on KSC is important to their entire population. Approaches used to quantify species' biological patterns on KSC allow researchers to address a variety of operational issues. Seven examples of current projects are discussed here.

The Atlantic loggerhead (Caretta caretta) is a marine turtle that was federally listed as threatened in 1978. The east coast of Florida, including KSC area beaches, supports the second largest density of nesting loggerheads in the world and surveys have been done on the KSC beach since 1976. A study on the effects of sand temperature on the sex determination of loggerhead hatchlings showed that eggs incubated on the KSC beach produced 95% females, while the majority of hatchlings produced in cooler North Carolina

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Regional Conference Proceedings 1993

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were males (Mrosovsky and Provancha 1992). These results point out the importance of the KSC beach to the survival of the Atlantic loggerhead population, as well as the potential problems associated with artificial hatching techniques that are commonly used in areas where nesting turtles and coastal development conflict.

The southeastern beach mouse (Peromyscus polionotus niveiventris) was listed as threatened in 1989, and inhabits the dune and adjacent coastal strand (Humphrey 1987) from Volusia County south to Broward County (Stout 1992). Extensive development and high recreational use of Florida's east coast has isolated the generally undeveloped stretch of beach on CCAFS, KSC, and CNS; it is expected to be the major stronghold for a sustainable population of the southeastern beach mouse in the future (Paradiso 1989). A mark/recapture study was done in 1990 and 1991 on several portions of the KSC beach. Five hundred thirty-nine beach mice were captured in six habitat types. The sex ratio was 52% males to 48% females, and most reproductive activity occurred in the winter (Provancha and Oddy unpub. data). These data will be used as a basis for more detailed studies to estimate population size and habitat preferences on KSC and CCAFS dunes.

The brackish water estuaries of KSC, collectively belonging to the Indian River Lagoon System, seasonally support a significant portion of the remaining West Indian manatee (Trichechus manatus) population (Provancha and Provancha 1988). Federally listed as endangered in 1972, the total Florida population is estimated to be 1,800 animals (Florida Department of Natural Resources 1992 personal communication). Aerial surveys for manatees have occurred on KSC since 1977. Within the last 15 years, the abundance of manatees in KSC waters during the spring has increased five-fold (Provancha and Provancha 1988). The distribution and abundance of the manatee's major food source, submerged aquatic vegetation (SAV), have been mapped for KSC. These maps are used to compare with manatee distributions determined from the aerial surveys and to evaluate effects of NASA operations in and near the estuary. Studies using exclosures are also occurring to quantify the influence of manatee grazing on SAV.

The estuary and wetlands on KSC provide habitat for a variety of wading birds, shorebirds, and waterfowl (Breininger and Smith 1990). The wood stork (Mycteria americana) is listed as endangered, and many other waders are protected by Florida laws. Monthly surveys of wading birds have occurred in the major feeding habitat types since 1987. Surveys are done yearly at colony sites to determine the number of breeding pairs. Data from the first three years show that the number of birds using KSC fluctuates greatly between years. When averaged, numbers are lowest in the winter, begin increasing in February and March, are highest during the spring nesting season, and decline after the young fledge in late summer and fall (Smith and Breininger 1992). Densities were calculated for each of the major feeding habitat types: mosquito control impoundments, the estuary, and roadside ditches. Most wading birds use impoundments for feeding, especially the open water areas, indicating the importance of mosquito control impoundments to regional populations (Smith

and Breininger 1992). This information assists in predicting effects on nesting and feeding habitat near Space Shuttle operational areas, and understanding effects of water level management activities in impoundments.

Because development in wetlands is extensively regulated, most new construction is in uplands, especially scrub and pine flatwoods. These habitats range from well to poorly drained and are fire-maintained communities (Schmalzer and Hinkle 1992). Scrub habitat types support many endemic species of plants and wildlife. The best known of these is the Florida scrub jay (Aphelocoma coerulescens coerulescens), a disjunct race of the scrub jay that is widespread in the western U.S. and Mexico. The Florida scrub jay was listed as threatened in 1987; statewide numbers have declined drastically because of development in scrub habitat (Cox 1987, Fitzpatrick et al. 1991). The Florida scrub jay has evolved a social system where a monogamous pair of breeders defends a permanent territory year-round with only minor boundary changes over time. Young produced by the breeding pair stay in the territory for one or more years post-fledging, helping with territory and nest defense, care of subsequent young, and detection of predators (Woolfenden and Fitzpatrick 1984). KSC supports the largest remaining population of Florida scrub jays with an estimated 2400 birds (Breininger 1989). Long-term studies of basic demographic parameters such as territory size, family size, habitat characteristics, and reproductive success have been on-going at two study sites since 1987. Family size ranges from two to eight birds, and average territory size ranges between 2.4 and 10.0 ha, depending on habitat type (Breininger and Smith 1989, Breininger et al. 1991). Potentially optimal habitat and scrub jay population centers on KSC have been identified. The population centers comprise less than 2% of KSC lands, but approximately 86% of the scrub jay population occurs within them (Breininger et al. 1991). Data from the long-term study sites help determine the habitat characteristics that define areas where reproduction exceeds mortality (population sources) versus areas where mortality exceeds reproduction (population sinks). This information is used to quantify and mitigate effects of development in scrub and pine flatwoods habitats and enhance habitat management.

Another uplands inhabitant is the gopher tortoise (Gopherus polyphemus), a state-listed species that is potentially endangered throughout the southeast U.S. due to habitat destruction and harvesting. Burrows constructed by gopher tortoises are important for at least 39 invertebrate and 42 vertebrate species, several of which are federally or state listed (Cox et al. 1987). It has been estimated that gopher tortoises will be eliminated from all privately owned lands in Florida by 2025 A.D. (Auffenberg and Franz 1982). Their conservation on public lands is essential, and KSC is the largest protected area on the east coast of Florida. Studies on KSC have shown that tortoise densities are highest where there is a diverse cover of herbaceous plants, their principal food. The average density in scrub and slash pine flatwoods on KSC was 1.3 tortoises/ha (Breininger et al. 1988). Radio-tagged animals used multiple burrows within their home ranges, including flooded burrows. Males used more burrows than females and had larger home ranges. There was less movement between burrows in the winter (Smith et al. 1992).

These data are not only important for understanding basic tortoise biology, but also to refine management guidelines that are used throughout Florida.

One of the commensals using gopher tortoise burrows on KSC is the eastern indigo snake (Drymarchon corais couperi), a federally listed threatened species since 1978. Radiotracking studies on KSC have shown that indigos are much less habitat specific than previously believed and use a wide variety of uplands and wetlands (Kehl et al. 1991). Average home range size was 280 ha for three males and 100 ha for three females; these estimates will become more refined as data from other radio-tagged individuals are analyzed. There is some evidence that males' home ranges do not overlap each other, but that male and female home ranges do overlap (Kehl et al. 1991). The use of such a wide variety of habitats and large areas makes the indigo a species of concern for operational impacts, particularly cumulative effects of habitat fragmentation by roads. Information on their habitat requirements is important for predicting and minimizing these impacts. Using the radio telemetry data and information on the amount of available indigo habitat, it has been estimated that approximately 300 indigos occupy KSC, which is near the acceptable minimum viable population size (Breininger et al. in prep.). The loss of a top level predator such as the indigo has unknown consequences for ecosystem integrity.

The conservation of biological diversity is being recognized as a proactive approach for managing wildlife and wildlife habitat. A specific example of this philosophy on KSC is the implementation of a scrub mitigation program. In an agreement between NASA/KSC and the USFWS, compensation will be made for scrub habitat that is lost to construction. This compensation will include restoration of scrub that has not been burned for many years and is overgrown, and the creation of scrub habitat on abandoned orange groves that formerly supported uplands. In scrub restoration areas, sections of overgrown vegetation are mechanically chopped down, allowed to dry, and the slash is burned. Thereafter, a schedule of controlled burns designed to emulate natural conditions will maintain a natural scrub habitat structure. In creation areas, old citrus trees are removed, the weeds are chemically treated and mowed, and a schedule of planting commences, beginning with small scrub oaks followed by a variety of native scrub plants. These areas will be burned in a manner mimicking natural fires. In restoration and creation sites, small mammal, amphibian, and reptile populations are monitored, and the changes in scrub jay habitat use, reproductive success, and survival before and after treatment are being investigated.

Long-term goals for the future of wildlife studies on KSC emphasize its role in maintaining local, regional, and global biological diversity. In addition, the KSC Stategic Plan (NASA 1991) documents initiatives to minimize impacts to the environment, enhance environmental awareness of the workforce, and continually update and improve monitoring and management techniques. We believe these goals can be reached with careful planning and management, and that it is possible to preserve KSC's unique natural environment in harmony with one of man's greatest technological achievements.

Acknowledgements

These studies were conducted as part of the NASA/KSC Long-term Environmental Monitoring and Research Program under the guidance of the Biomedical Operations and Research Office. Numerous individuals have contributed to the field work, data analysis, and report preparation that are summarized in this paper, and we thank them for their efforts and dedication. Helpful comments were provided for this manuscript by C.R. Hall, P.A. Schmalzer, J.A. Provancha, and B.R. Summerfield.

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